TECHNICAL REPORT
67-53-CM

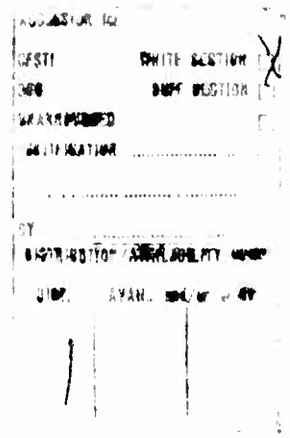
ADVANCES IN THE DEVELOPMENT OF HEAD PROTECTION FOR AIRCRAFT CREWMEN

by
Abraham L. Lastnik

February 1967

UNITED STATES ARMY
NATICK LABORATORIES
Natick, Massachusetts 01760

Clothing and Organic Materials Division
C&ED-45



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Clothing and Organic Materials Laboratory
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FOREWORD

The Federation of American Societies for Experimental Biology conducted a conference on the military implications of protective devices designed to prevent or ameliorate head and neck injuries for the Life Sciences Division, Army Research Office, Office of the Chief of Research and Development on 2, 3, and 4 March 1966 in Bethesda, Maryland.

The objective of this conference was to review the mechanical, physiological and neurological natures of head and neck injury. Also discussed was the current research related to head and neck injuries and current protective devices for the head and neck.

This report, which is the text of these Laboratories' presentation at the conference, presents a discussion of the Army's efforts to provide head protection to Army aircrewmen.

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ABSTRACT

The U.S. Army's new nylon fabric laminate flight helmet provides increased crash and ballistic protection over that of other current U.S. military flight helmets. A newly developed retention device, based on an orthopedic sling for neck traction, assures retention of the helmet. A new visor of polycarbonate resin provides eye protection against impinging fragments. It resists shattering and penetration. Research studies reveal the feasibility of attenuating low frequency noise, at the ear, with relatively small volume ear cups.

ADVANCES IN THE DEVELOPMENT OF HEAD PROTECTION FOR AIRCRAFT CREWMEN

The U. S. Army Natick Laboratories, in addition to creating a number of protective devices for the American serviceman, is engaged in research and development programs oriented to prevent or ameliorate head injuries resulting from aircraft accidents.

The following presents the Laboratories' most recent accomplishments regarding areas of:

1. Crash protection
2. Ballistic fragment protection
3. Helmet retention
4. Eye protection
5. Noise protection at the ear

The Army's new flight helmet shown in Figure 1 resembles the currently used APH-5 helmet. It weighs approximately four pounds. This helmet has superior impact energy attenuating capabilities than that of the APH-5 helmet. This increased protection was accomplished, primarily, by substituting a nylon fabric laminate for the glass fabric shell of the APH-5 helmet.

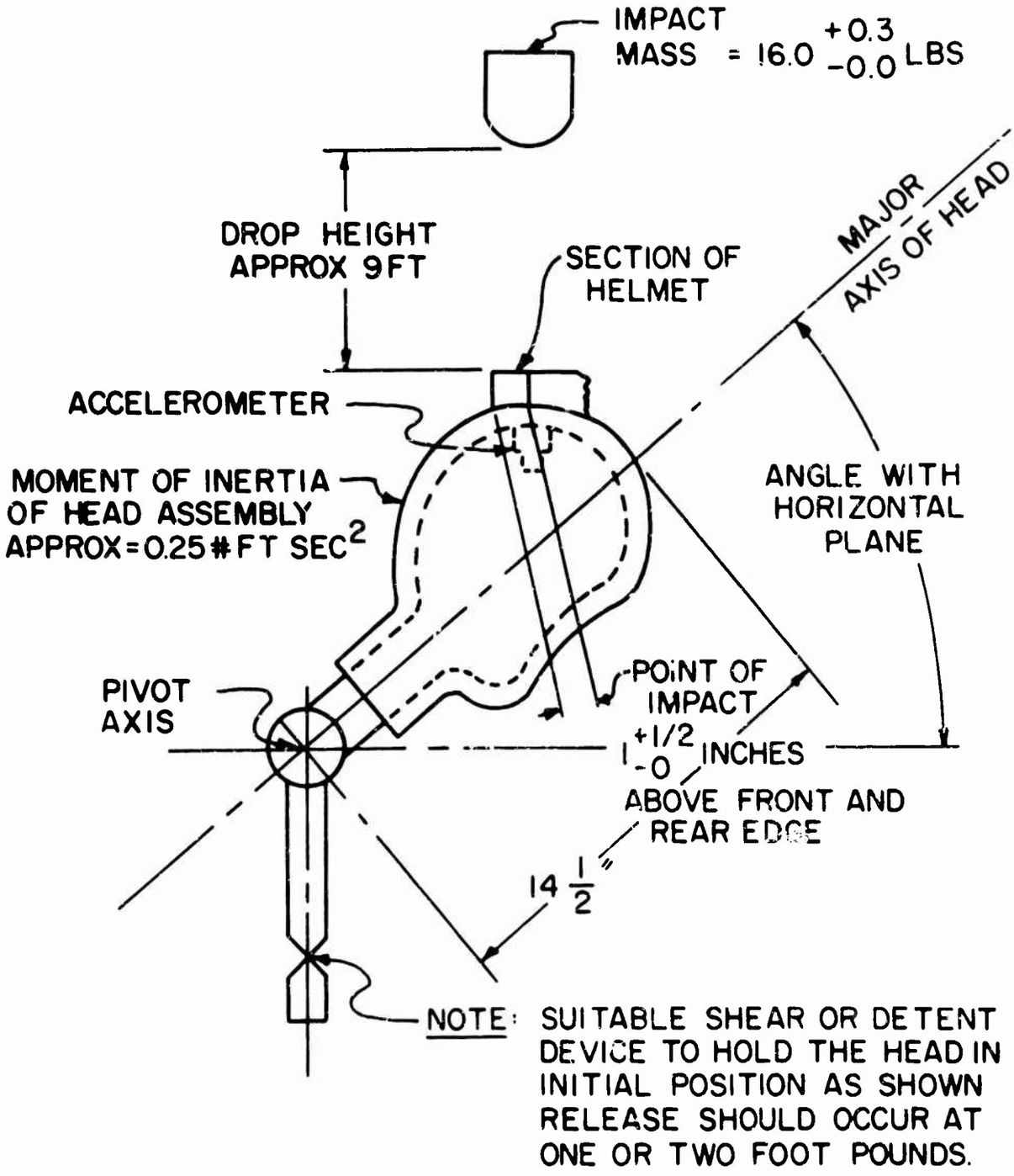
Figure 2 is a schematic of the impact test apparatus used to evaluate the helmet. A 16-pound weight with a 1.9-inch radius striking surface is dropped onto a helmet fitted to a free-swinging hollow headform. An accelerometer is mounted on the inner surface of the headform, directly below the point of impact. All blows are made normal to the helmet surface. All test helmets consisted of the shell, foam lining, and ear cushions to stabilize the helmet on the headform.

This test method developed by the Snell Memorial Foundation is required by the Navy for testing their APH-6A helmet and is one of the methods being considered by the American Standards Association Committee Z90 on vehicular head protection.

The APH-5 and new nylon helmets were first tested against the Navy's impact requirements which state that a 100 foot-pound impact shall not cause the helmet to bottom nor shall an excess of 400 G's be generated.

A 100 foot-pound impact generated 300 G's with the APH-5 helmet and only 90 G's with the nylon helmet. The duration of impact for the APH-5 was 2 to 4 milliseconds and 7 to 8 milliseconds for the nylon helmet. A second impact in the same site resulted in 600 G's with the APH-5 and 100 G's with the nylon helmet. The duration of impact was 2 to 4 milliseconds and 7 to 8 milliseconds, respectively.

Figure 1. U. S. Army Helmets, Flying, Protective:
(Left) Helmet, Flying, Crash Type (new nylon fabric helmet)
(Right) Helmet, Flying Protective, APH-5 Type
(Glass Fabric Helmet)



SCHEMATIC: HELMET IMPACT TEST APPARATUS

Figure 2. Helmet Impact Test Apparatus

Further impact testing of the nylon helmet showed that it would sustain two successive 160 foot-pound impacts in the same area, recording no more than 300 G's for each impact. The duration of each impact was not less than 6 milliseconds.

The helmet's resistance to ballistic penetration, when tested with a standard fragment simulator, is similar to that afforded by the M-1 helmet of World War II and Korea.

The helmet is made in two sizes, medium and large, designed to fit the 5th and 95th percentile head dimensions of air crewmen. The method of making the helmet shell precludes a smooth and dimensionally controlled inner surface. This variable may very well be reflected in an inability to fit the intended population with only two sizes. Universal use of the helmets should determine the need for a third and larger size.

The pilot in Figure 3 appears to be wearing a high collar. This is part of a new retention harness that will hold the helmet on the head better than the chin-strap and nape-strap combinations now being used. This retention harness is similar to an orthopedic sling used to achieve neck traction.

Because the harness is made of nylon, there was concern that it could be a fire hazard. However, it can be made from Nomex, a non-melting, non-burning member of the nylon family.

Figure 4 is a copy of an instruction sheet showing how the retention harness may be retrofitted to the Army, Navy, and Air Force helmets. The harness is now being tested for user acceptance. Samples were furnished to both the Air Force and Navy.

It appears that little consideration had been given to eye protection. The acrylic visor developed for the original flight helmet is still being used although it shatters, spalls and burns quite readily. New visors, however, developed by the U.S. Army Natick Laboratories will not shatter, spall or burn. These new visors are made from polycarbonate resin (known as "Lexan" or Merlon" and produced by the General Electric Company and the Mobay Company, respectively).

The polycarbonate visor also resists penetration of fragments or missiles. Both acrylic and polycarbonate visors were shot with a standard test missile identified as a .22 caliber, 17-grain fragment simulator. At impact velocities of 400 feet per second, the missile penetrated the acrylic visor, caused spall and continued on its flight path with little apparent reduction of velocity. The polycarbonate visor can stop missiles with impact velocities of 600 feet per second.

Figure 3. Pilot wearing Helmet with a Retention Harness

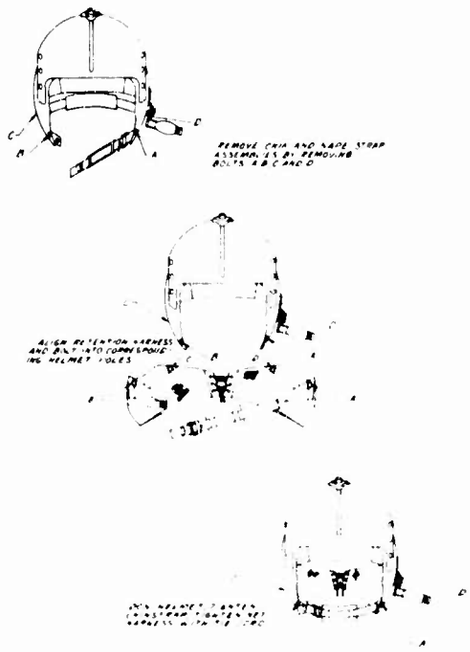


Figure 4. Instruction Sheet Illustrating the Method of Retrofitting the Retention Harness to Army, Navy, and Air Force Helmets.

Noise attenuation, an important area of head protection, was not improved in the new helmet. Figure 5 shows the noise spectra of three Army aircraft. The dotted line shows the recommended maximum steady-state noise level for Army Materiel Command equipment. The apparently insoluble problem is to attenuate noise frequencies below 600 cycles per second within the narrow confines of the helmet shell. To accomplish this would require an expansion of the state-of-the-art.

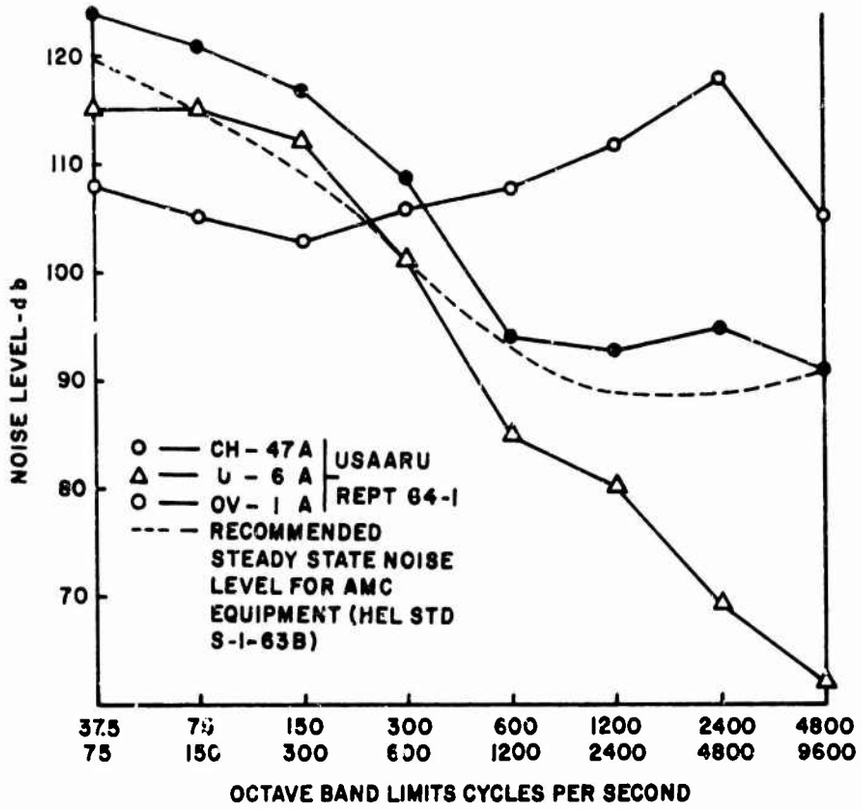


FIGURE 5 NOISE ENVIRONMENT AT PILOT'S EAR IN THREE ARMY AIRCRAFT AT CRUISING SPEED AND RECOMMENDED STEADY STATE NOISE LEVEL FOR AMC EQUIPMENT

There are now, however, signs of a breakthrough. Figure 6 shows the attenuation curve of the APH-5 helmet compared with attenuation curves for two new concepts which show extraordinary attenuation characteristics in the low frequency range. Concept 1 involves the use of a Helmholz resonator. This was explored under contract with CBS Laboratories, Stamford, Conn. This concept is about to enter a developmental phase to incorporate it into a helmet. Concept 2 appears to be a radically new approach to ear-cup-type protectors that will permit more than 20 db attenuation at low frequencies with relatively small volume cups. This concept cannot yet be discussed freely until certain proprietary considerations are resolved.

Material and design research at the U. S. Army Natick Laboratories are combining to provide aircraft crewmen with a greater measure of head protection than has been achieved in the past.

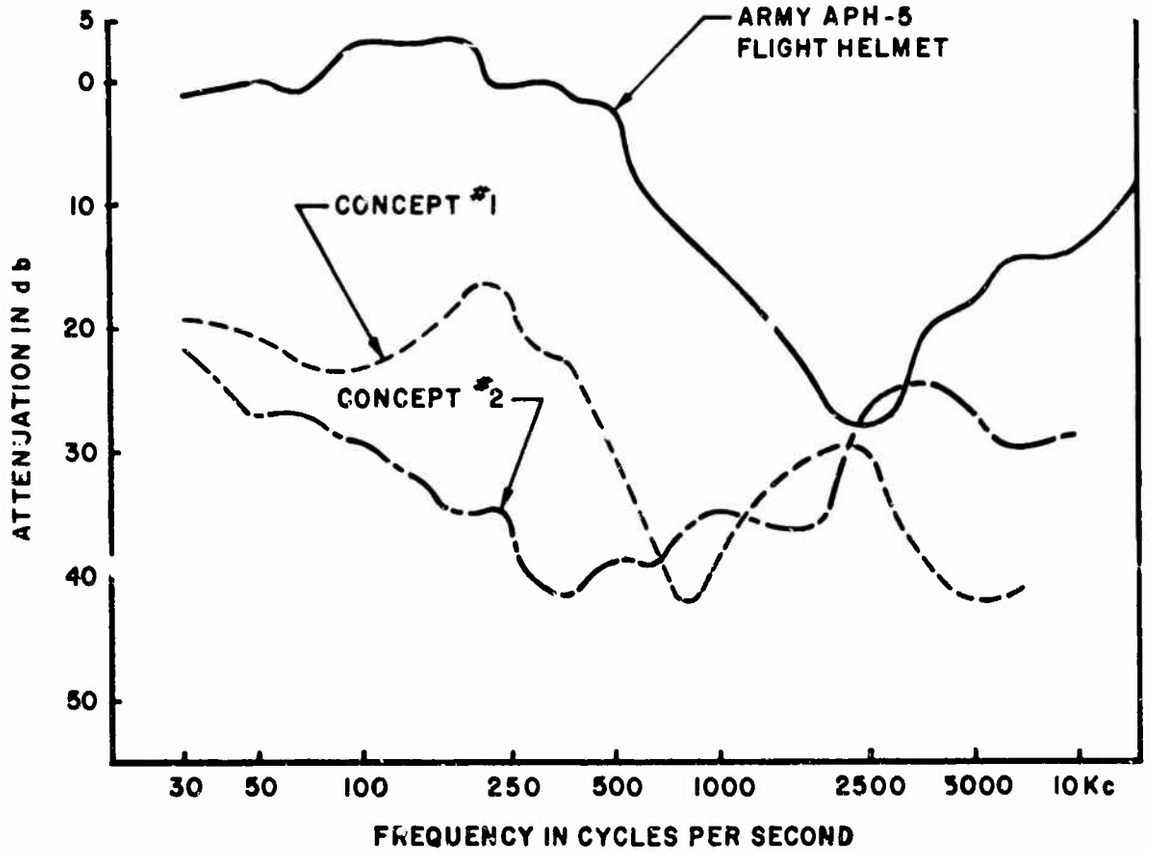


FIGURE 6. NOISE ATTENUATION CURVES FOR THE ARMY APH-5 FLIGHT HELMET AND THE NOISE ATTENUATION POTENTIAL OF TWO CONCEPTS

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